ANGULAR LASER CONTROL

BACKGROUND OF THE INVENTION

In the optical communication industry there is a need for testing e.g. optical components and amplifiers with lasers at different wavelengths. For this purpose, various types of external cavity type lasers are known.

SUMMARY OF THE INVENTION

It is an object of the invention to improve control of external cavity type lasers. The object is solved by the independent claims. Preferred embodiments are shown by the dependent claims.

An external-cavity type laser unit in the context of the present invention comprises a laser gain medium arranged in an external cavity having a reflecting dispersion device. The laser gain medium provides a first beam towards the reflecting dispersion device and a second beam in another direction than the first beam. The reflecting dispersion device receives the first beam and reflects a beam towards the laser gain medium, wherein the reflecting angle is dependent on the wavelength.

Such external-cavity type laser unit can be embodied, for example, following the so-called Littman geometry (as disclosed e.g. in "Liu and Littman, Novel geometry for single-mode scanning of tunable lasers, Optical Society of America, 1981"), the so-called Littrow geometry (as disclosed e.g. in EP 0 952 643 A2), or the Bragg-reflector type cavity (are shown e.g. in "A. Nahata et al., Widely Tunable Semiconductor Laser Using Dynamic Holographically-Defined Distributed Bragg Reflector, 2000 IEEE"). The teaching of those documents shall be incorporated herein by reference.

It is known, e.g. from EP-A-951112, that monitoring the reflecting angle allows deriving information about the difference between oscillation and selected

wavelength. While this monitoring relates to the beam reflected from the reflecting dispersion device in response to the first beam, an angular displacement of the second beam has never been considered. However, according to the present invention, such angular displacement of the second beam is utilized for controlling the laser unit.

In particular in case the second beam, e.g. as output beam of the laser unit, is for example to be coupled into an optical fiber or is directed e.g. to a measuring unit (e.g. a power meter or a wavemeter as disclosed e.g. in EP-A-0875743 by the same applicant), it has been found that angular variations of the second beam can have significant impact on the performance such as coupling ratio or measuring accuracy.

Therefore, according to the present invention, a control unit is provided for controlling the laser unit and comprises an angle unit for providing an angular variation signal indicative of an angular variation of the second beam. Further, the control unit comprises an analysis unit for receiving the angular variation signal and controlling the reflection angle of the reflecting dispersion device dependent on the angular variation signal.

In a preferred embodiment, the angle unit comprises an angle detection unit adapted for detecting the angular variation of the second beam and deriving the angular variation signal in correspondence with the detected angular variation. Such angle detection unit allows to directly determining the angular variation.

Preferably, the angle detection unit comprises a position dependent detector adapted for receiving the second beam, or a part thereof, and detecting the angular variation from a lateral variation of the received beam detected along the position dependent detector. By increasing the distance between the laser gain medium and the position dependent detector, the sensitivity and measurement range can be adjusted. Alternatively or in addition, the angle

detection unit might comprises two power detectors each receiving a portion of the second beam, wherein the ratio of the two portions depends on the angular variation of the second beam. This simple configuration allows to measure, at the same time, the power that can be used for monitoring the power or even regulating it. Instead of using the angle detection unit, the angle unit might derive the angular variation signal e.g. from the coupling efficiency of the beam to a receiver with a small numerical aperture, for example a single mode fiber. If the position of the receiver is shifted with respect to the nominal position, an ambiguity whether the beam rotates in one or the other direction can be resolved. A beam splitter might be used in one embodiment for receiving and splitting the second beam into one portion to be provided to the angle unit and into another portion to be provided to a coupling unit for coupling out the received portion of the second beam, preferably into an optical fiber or any other type of optical signal carrier. This allows to utilize the other portion e.g. as output beam of the laser unit.

A power detector can be used for determining a power value indicative of the total power of the second beam. This power detector can be used to monitor or regulate the total power from the laser unit. Preferably, the angle unit is adapted to determine the angular variation signal based on power value indicative of power received by the optical fiber and the determined power value indicative of the total power of the second beam. The power received by the fiber can be used for monitoring or regulating the optical power available at the fiber. The analysis unit can be used for controlling the reflection angle to keep the angular variation substantially constant, preferably with respect to a reference angle, and preferably to be substantially zero or another predetermined value. This allows maximizing or at least controlling the ratio of the power received by the fiber compared to the power of the second beam. For controlling the reflection angle, the analysis unit preferably controls at least one of a rotation, a shift, and a lateral shift of the reflecting dispersion device.

In a preferred embodiment, the control unit comprises a modulator for modulating the reflection angle of the reflecting dispersion device with a modulation signal, preferably by modulating around a center value. The analysis unit derives an error signal by analyzing the modulated angular variation signal in conjunction with the modulation signal, and controls the reflection angle of the reflecting dispersion device dependent on the derived error signal. Any ambiguities (not already resolved by the detector) can then be determined, especially the sign of the error can be measured. The laser gain medium preferably comprises an amplifying waveguide or an amplifying medium in general like a doped crystal or glass, a gas cell or a dye cell. The reflecting dispersion device may comprise one or more gratings or dispersion prisms, one or more gratings or dispersion prisms with one or more mirrors or other reflecting devices like dihedral elements or retroreflecting cubes or any other device, where the reflection angle substantially depends on the wavelength of the incident light, either with a fixed or with a tunable characteristic. The invention can be partly or entirely embodied or supported by one or more suitable software programs, which can be stored on or otherwise provided by any kind of data carrier, and which might be executed in or by any suitable data processing unit. Software programs or routines are preferably applied to calibrate the target value for the angle to be detected by the angle detection unit or to calibrate the ratio of powers in the fiber and the total power of the second beam and in general to build the regulation.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and many of the attendant advantages of the present invention will be readily appreciated and become better understood by reference to the following detailed description when considering in connection with the accompanied drawing(s). Features that are substantially or functionally equal or similar will be referred to with the same reference sign(s).

Fig. 1 shows an example of an embodiment of a laser unit 10 according to the present invention.

MORE DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS ACCORDING TO THE INVENTION

In Fig. 1, the laser unit 10 comprises a laser gain medium 20 and an external cavity 30 having a reflecting dispersion device 40. In the example of Fig. 1, the reflecting dispersion device 40 comprises a grating 50 and a retro-reflecting mirror 60, which can be a plain mirror, dihedral element, etc. Accordingly, the external cavity 30 in Fig. 1 extends between the mirror 60 and an end facet 70 of the laser gain medium 20 facing towards the collimating optics 130.

A lens or any other collimating optics 80 can be provided to collimate a first beam 90 emitted from the laser gain medium 20 towards grating 50 of the reflecting dispersion device 40. The grating 50 receives and diffracts the first beam 90 dependent on the wavelength of the first beam 90. A portion 100 of the diffracted first beam 90 is reflected back by the mirror 60 and will be diffracted by the grating 50 as a beam 100A towards the laser gain medium 20.

The elements 20 to 100 thus represent a so-called Litman-architecture. Continuous and mode-hop free tuning can be achieved (at least in theory) when rotating the mirror 60 (as indicated by the angle 60A) around a pivot point 110.

Thus, the reflecting dispersion device 40 receives the first beam 90 and reflects back the beam 100A towards the laser gain medium 20 having a reflection angle dependent on the wavelength. In normal operation, the reflection angle leads to a beam 100A parallel to the beam 90 but in case of a mismatch the beam is reflected into a different direction shown as dotted beam 100B.The laser gain medium 20 provides a second beam 120 in opposite direction than the first beam 90. In the embodiment of Fig. 1, the second beam

120 represents the output beam of the laser unit 10 and is collimated by a collimator 130 towards a beam splitter 140. The beam splitter 140 splits up the second beam 120 into a portion 120A directed towards an angle detection unit 150 and into a portion 120B directed towards and being focused by a lens 160 into a fiber 170. A detector 175 might be coupled to the fiber 170 for detecting optical power received at the fiber 170.

The angle detection unit 150 detects an angular variation (dotted lines in Fig. 1) of the second beam 120, and an angle unit 180 derives an angular variation signal indicative of an angular variation of the second beam in correspondence with the detected angular variation. An analysis unit 190 receives the angular variation signal and might receive the power detected by the detector 175 and controls the reflection angle of the reflecting dispersion device 40 dependent on the angular variation signal. This can be accomplished by rotation and/or shifting the grating 50 or the mirror 60 as indicated by the arrows. By rotating or shifting the grating or the mirror, the reflected beam 100B can be rotated so that the direction is antiparallel to the beam 90.The angle detection unit 150 can be embodied e.g. as a position dependent detector detecting a lateral variation of the received beam 120 detected along the position dependent detector.